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THE COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

Docket No. TS2000-023

Sir:

Transmitted herewith for filing is the Patent Application of:

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For: PHOTORESIST STRIPPER USING NITROGEN BUBBLER

Enclosed are:

- ☒ 5 sheets of drawing(s) - formal.
- ☒ An assignment of the invention to Taiwan Semiconductor Manufacturing Company
- ☐ An associate power of attorney

The filing fee has been calculated as shown below:

	(Col. 1)	(Col. 2)	OTHER THAN A SMALL ENTITY	
FOR:	NO. FILED	NO. EXTRA	RATE	FEE
BASIC FEE				\$ 690.
TOTAL CLAIMS	17 -20=	0	x 18 =	\$ 0.
INDEP CLAIMS	6 -3=	3	x 78 =	\$ 234.
MULTIPLE DEPENDENT CLAIM PRESENTED			+ 260 =	
			SUB TOTAL	\$ 924.
			ASSIGNMENT	\$40.
			TOTAL	\$ 964.

- ☒ Please charge my Deposit Account No. 19-0033 in the amount of \$ 964. A duplicate copy of this sheet is enclosed.
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- ☒ Any additional filing fees required under 37 CFR \$1.16.
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Respectfully submitted,
George O. Saile
GEORGE O. SAILE, REG. NO. 19,572

PHOTORESIST STRIPPER USING NITROGEN BUBBLER

BACKGROUND OF THE INVENTION

(1) Technical Field

The present invention relates to semiconductor manufacturing. More specifically, the invention teaches an improved fluid application systems for stripping photoresist from silicon wafers, particularly wafers having dense top metal circuit patterns with sidewalls which obscure residual photoresist, and the like.

(2) Description of the Prior Art

The following four documents relate to methods dealing with stripping and cleaning of substantially planar objects.

U.S.Pat.No. 4,251,317 issued February 17, 1981 to Foote, shows a gas bubbler in combination with a wafer cassette rotation within a wet wafer cleaning tank.

U.S.Pat.No.5,868,898 issued February 9, 1999 to Liu et al., shows a wet wafer cleaning tank with a fluid distributor to agitate the stripper and form bubbles.

U.S.Pat.No.5,704,981 issued January 6, 1998 to Kawakami et al., recites a buffer plate for distributing gs in a reactor.

U.S. Pat.No.5,954,885 issued September 21, 1999 to Ohmi, shows a cleaning method using wet tanks and ultrasound.

U.S.Pat.No.5,464,480 issued November 7, 1995 to Matthews, shows a gas diffuse for a organic stripping/cleaning tank.

During the forming of integrated circuits on semiconductor wafers, several process steps require submersing the wafers in liquid chemicals contained in an immersion tank is generally a practical high-throughput, flexible fabrication process. Examples include, chemical etching, photoresist stripping, and wafer cleaning. In a typical wet chemical process tank, in order to ensure a perfect mix of acids, detergents and the like or a good uniformity in the acid itself, constant stirring or agitation of the solution in the tank is desired. While mechanical stirring or agitation techniques have been used, the moving components of a stirrer frequently generate contaminant particles that are detrimental to the wafer surfaces. An example of a chemical process system equipped with a bubbler and a mechanical cassette rotating apparatus is shown in FIG. 1.

The apparatus illustrated schematically in FIG. 1 is of the prior art. As shown in that figure, is a tank 10 which contains liquid etchant 12 in the form of an acid bath. The tank has a mechanism 20 mounted thereto, wherein a housing 22 is rotatably mounted and driven with a sprocket and chain combination 30 by a motor (not shown). A cassette 40 containing wafers 42 is supported therewithin housing 22. The housing 22 and cassette 40 have appropriate openings therein so that etchant 12 may reach the wafers 42. A manifold 54 running transversely and adjacent the bottom of the tank 10. The longitudinal axis of the manifold 54 being substantially parallel to and directly below the axis of rotation of the housing 22. The manifold 54 defines a plurality of evenly-spaced openings along the upper surface thereof. Nitrogen gas is supplied through tubes 52.

The gas bubbles 60 travel in a direction 62 generally perpendicular to the axis of rotation of the cassette 40.

The fabrication of integrated circuits on a semiconductor wafer involve a number of steps where patterns are exposed through lithographic photomasks into a photosensitive resist covering the wafer. After developing, open areas in the photoresist permit subsequent processes such as inclusion of impurities, oxidation, etching, and metalization to be performed. The photoresist is thereafter stripped from the wafer following each of the aforementioned process steps. From a chemical reaction point of view, conventional methods for stripping photoresist have low reaction rates due to the low collision frequency between the stripper and photoresist molecules. . Furthermore, from a thermodynamics point of view, the activation energy of photoresist molecules dissolving into the stripper is intensified under static conditions, thus leaving residues on the wafers in view of the fact that an incomplete chemical reaction takes place in a limited processing time. The process suffers the risk of re-depositing the dissolved impurities onto the wafer in a viscous static stripper due to the low solubility of the photoresist..

During latter stages of circuit fabrication, the forming of various metal conductive layers transform the wafer's topographic surface into a three dimensional maze of metal circuit lines that are closely separated, thereafter, making the circuit line's sidewall height proportional in size to its width and spaces. The process of stripping the photoresist from between these three dimensional circuit lines becomes increasingly challenging, particularly on the 6 and 8 inch diameter wafers. Residues left behind are harmful contaminants to the microscopic circuits which the fabrication process creates.

The apparatus of FIG. 1, having a rotating mechanism immersed in the process chemical, conventionally used when etching wafers, is not recommended for use during photoresist stripping or for cleaning wafers because of particulate generated by the cassette rotating drive members, hence, contaminating the process chemicals and also the wafers being processed.

SUMMARY OF THE INVENTION

It is therefore a primary object of the present invention to provide a method for effectively stripping obscured photoresist or other organic materials from semiconductor wafers having dense top surface conductive patterns with prominent sidewalls.

Another object of the present invention is to provide an apparatus that manifests a scrubbing action with a directional agitation of the viscous stripper that is against the immersed wafer's surface using nitrogen bubbles moving upward and parallel to the dense top surface conductive patterns thus increasing the collision frequency between the stripper and photoresist molecules.

It is yet another object of the present invention to increase the throughput due to the efficient stripping rate promoted by increased solubility.

It is still another object of the present invention to prolong the lifetime of the stripper by reducing the stripping process time.

It is still another object of the present invention to improve the stripping uniformity within a wafer and to eliminate the boundary condition of the tank.

In accordance with the objects of this invention a new and improved method and apparatus for effectively stripping photoresist from the large diameter semiconductor wafers having dense top surface conductive patterns with protuberant sidewalls is achieved. The method provides a scrubbing action that is parallel to the device array being formed on the wafer's surface. Broadly stated, the method of a chemical action on large wafers supported adjacent respective edge portions thereof in a cassette includes submerging the cassette and wafers supported thereby in a tank containing a liquid chemical, and a gas distribution plate disposed on the bottom of the tank for directing nitrogen bubbles upward and parallel to the surfaces of each wafer contained in the cassette to ensure that a uniform and accelerated chemical action occurs. This novel method and apparatus would be of great value to the semiconductor industry.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a side elevation of an etching tank of the prior art.

FIG. 2 is a perspective side elevation view of the apparatus for practicing the present invention.

FIG. 3 is a bottom view illustration of the gas distribution plate of the invention.

FIG. 4 is a top view illustration of the gas distribution plate of the invention.

FIG. 5 is an enlarged plan view of a portion of a cassette used for supporting wafers during processing, showing wafers contained therein.

FIG. 6 is an enlarged view showing the edge portion of the sinuous groove with a cross-section of the flexible tube therein.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In a preferred embodiment, the process of the invention is conducted by the apparatus of FIG. 2, is characterized by a gas distribution plate 20 in which a gas supply manifold directs gas bubbles 11 from the bottom of a process tank 51 upward and between wafers 10 contained in a cassette 12 and supported therewithin. This improved method and apparatus is used for effectively stripping photoresist from the larger semiconductor wafers having dense top conductive patterns with protuberant sidewalls. The method provides a scrubbing action that is parallel to the device array being formed on the wafer's surface. Broadly stated, the method of a chemical action on large substrates supported adjacent respective edge portions thereof in a carrier includes submerging the carrier and substrates supported thereby in a process tank containing a liquid chemical, and a gas distribution plate disposed on the bottom of the tank for directing gas bubbles upward and parallel to the surfaces of each substrate contained in the carrier to ensure that a uniform chemical action occurs. This novel method and apparatus would be of great value to the semiconductor industry.

The process tank 51, illustrated in FIG. 2, is equipped with a gas distribution plate 20 for generating and directing gas bubbles 11 egressing in an upward direction and below a stationary plurality of semiconductor wafers 10 supported adjacent respective edge portions thereof while in a cassette 12. A fragmented view of the cassette 12 and tank 51 are shown to depict the bubble action against the surfaces of wafers. The open

process tank 51 having two sidewalls and two endwalls perpendicularly joined to a bottom wall for holding a process chemical 55. Two ports are located at opposite ends of a sidewall and proximal the bottom wall, each port containing a leakproof bulkhead fitting 56, 57 to facilitate connection for transmitting a pressurized and regulated gas supply 59 to the gas distribution plate 20.

A gas distribution plate 20 (GDP) having a top surface 22 separated from a bottom surface 21, is placed and supported by the bottom wall of tank 51 as best illustrated in FIG 2. For a more comprehensive and detailed description of the gas distribution plate 20, refer to FIGs 3 and 4. The bottom surface 21 illustrated in FIG.3 has a sinuous groove 23 shaped to form a plurality of parallel circuit legs 24 transversing the length of GDP 20, with alternate turnarounds 25 for establishing continuity, the circuit legs 24 have a periodicity matching the spacing between wafers 10 held in a process cassette 12. The cassette, conventionally used is illustrated in FIG 5. Sinuous groove 23 has a first path 26, and a second path 27 located on the same side and at opposite ends of the GDP, extending therethrough the side edge, as best illustrated in FIG. 6, of the gas distribution plate 20. A flexible tubing 30 is urged and guided into the length of the sinuous groove 23 extending therefrom first and second paths 26, 27 and connected thereto respective ports 56, 57 completing therein a circuit for conveying a pressurized and regulated gas supply to both paths leading to GDP 20. A multiplicity of spacers 28 are affixed to the bottom surface 21 raising the GDP off the bottom wall of process tank 51. facilitates flushing of the tank with a cleaning solvent between draining of degraded stripper and refilling with a fresh supply. In addition, elongated and open slots 29 running therethrough allow direct passage to the tank bottom for a more surface accessibility during flushing of the tank.

As shown in FIG. 4, the top surface of the gas distribution plate 20 has two rows 31 and 32 of holes 33, each of the rows widely separated from one another, and containing holes 33 that are equally spaced and paired opposite one another. The pairs of holes, transversing the length of GDP 20, are in alignment with and intersecting the center width of each circuit leg 24 located thereunder. After the flexible tubing 30 is inserted into sinuous groove 23, holes 38 are drilled to break through the top side of the tubing 30. The location of the holes 38, as best illustrated in FIG. 6, are guided thereof by the holes making up the two rows 32, 33 on the top surface of the distribution plate.

The process of enhancing the scrubbing action for stripping photoresist from semiconductor wafers 10, particularly the larger wafers having dense top conductive patterns with protuberant sidewalls, can now begin. A plurality of wafers 10, supported apart each other by adjacent respective edge portions are contained within a cassette 12. The spacing between wafers approximately matches the spaces between circuit legs 24. The wafers 10 are supported vertically adjacent respective edge portions thereof while in the cassette 61 with appropriate openings therein so that the liquid stripping chemical contained in process tank 51 may reach the wafers. The cassette is submersed in the liquid stripper for soaking. A valve is opened, not shown, directing nitrogen and forming bubbles created by escaping nitrogen gas 59 egressing holes provided in tubing 30 traveling upward while scrubbing the surfaces of the wafers. It becomes quite evident that a highly efficient and effective method of stripping photoresist from semiconductor wafers is herewith disclosed.

While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that

1. Apparatus for fluid application to a plurality of substrates having surface patterns with prominent sidewalls comprising:
 - an open tank for holding a liquid chemical;
 - means to hold a plurality of substrates;
 - gas supply means;
 - a gas distribution plate means submerged and supported by bottom of said tank, said gas distribution plate generates and directs gas bubbles thereunder parallel to surfaces of substrates submerged thereabove.
2. Apparatus for fluid application to a plurality of semiconductor wafers having top metal lines with prominent sidewalls comprising:
 - an open tank for holding a liquid chemical;
 - means to hold a plurality of wafers;
 - gas supply means;
 - a gas distribution plate means submerged and supported by bottom of said tank, said gas distribution plate generates and directs gas bubbles thereunder parallel to surfaces of said wafers submerged thereabove.
3. The apparatus of claim 2 wherein said means to hold a plurality of wafers is a cassette having appropriate openings therein so that a liquid chemical may reach said plurality of wafers when said cassette is submerged.
4. Apparatus for stripping photoresist from a plurality of semiconductor wafers having top metal lines with prominent sidewalls comprising:
 - an open tank for holding a liquid stripper;
 - means to hold a plurality of wafers;
 - gas supply means;

30 a gas distribution plate means submerged and supported by bottom of
said tank, said gas distribution plate generates and directs gas bubbles
thereunder directed parallel to surfaces of said wafers submerged
thereabove.

35 5. The apparatus of claim 1 wherein said gas distribution plate includes:
a rectangular plate having a top surface separated from a bottom surface;
a sinuous groove disposed on said bottom surface forming a plurality of
straight and parallel segments with alternate turnarounds, said segments
transversing length of said plate;
sinuous groove having two inlets, a first inlet beginning proximal one
end of a long side edge of said plate, the other inlet exiting the same side
40 edge proximal the other end, and
a length of flexible tubing, having two ends, urged and guided into said
sinuous groove, said ends extending therefrom connected to said gas
source;
a multiplicity of spacer legs of equal lengths affixed to bottom surface of
45 said plate.

6. The apparatus of claim 5 wherein said spacer legs raise said plate from
bottom of said tank to facilitate tank cleaning and maintenance.

50 7. The apparatus of claim 1 wherein said top surface of said gas
distribution plate further includes:
a plurality of elongated slot openings extending from the top surface to
the bottom surface contiguously disposed between said parallel
segments, said slot openings transversing length of said plate;

55 two rows of a first set of holes, each row widely separated therebetween,
said holes equally spaced and forming pairs transversing length of
plate, said hole aligned and intersecting with the center width of
respective segments of said sinuous groove thereunder, and
two rows of a second set of holes drilled through a top wall of said tubing,
60 whereby location of said holes are guided therein by first set of holes.

8. The apparatus of claim 7 wherein said plurality of slot openings
facilitate tank cleaning and maintenance.

65 9. The apparatus of claim 1 wherein said GDP is made of a corrosion
resistant material.

10. The apparatus of claim 1 wherein said flexible tube is of a corrosion
resistant material.

70 11. A method for removing organic materials from a plurality of
substrates having surface patterns with prominent sidewalls comprising the steps
of:

providing an open tank containing a liquid chemical;
75 providing a gas distribution plate means submerged and supported by
bottom of said tank;
providing a gas supply means connected to said gas distribution plate;
providing carrier means containing a plurality of substrates, and
submerging and resting carrier means thereon gas distribution plate so
80 that substrates are totally submersed and supported vertically;

said gas distribution plate generates and directs gas bubbles thereunder and parallel to surfaces of substrates positioned thereabove.

12. A method for removing organic materials from a plurality of semiconductor wafers having top metal lines with prominent sidewalls comprising the steps:

providing an open tank containing a liquid chemical;

providing a gas distribution plate means submerged and supported by bottom of said tank;

providing a gas supply means connected to said gas distribution plate:

providing cassette means containing a plurality of wafers, and

submerging and resting cassette means thereon gas distribution plate so that wafers are totally submersed and supported vertically;

said gas distribution plate generates and directs gas bubbles thereunder and parallel to surfaces of wafers positioned thereabove.

13. The method of claim 12 wherein said means to hold a plurality of wafers is a cassette having appropriate openings therein so that a liquid chemical may reach said plurality of wafers when said cassette is submerged.

14. A method for stripping photoresist from a plurality of semiconductor wafers having top metal lines with prominent sidewalls, comprising the steps of:

providing an open tank containing a liquid stripper;

providing a gas distribution plate means submerged and supported by bottom of said tank;

providing a gas supply means connected to said gas distribution plate:

providing cassette means containing a plurality of wafers, and

submerging and resting cassette means thereon gas distribution plate so
that wafers are totally submersed and supported vertically;
110 said gas distribution plate generates and directs gas bubbles thereunder
and parallel to surfaces of wafers positioned thereabove.

15. The method of claim 11 wherein said gas distribution plate is made of
a corrosion resistant material.

115

16. The method of claim 11 wherein said flexible tube is of a corrosion
resistant material.

17. The method of claim 11 wherein said gas supply is a pressurized
120 and regulated nitrogen gas.

ABSTRACT

Provided is a process and apparatus characterized by a gas distribution plate in which a gas supply manifold directs gas bubbles from the bottom of a process tank upward and between wafers contained in a cassette and supported therewithin. This improved method and apparatus is used for effectively stripping photoresist from the larger semiconductor wafers having dense top conductive patterns with protuberant sidewalls. The method provides a scrubbing action that is parallel to the device array being formed on the wafer's surface. Broadly stated, the method of a chemical action on large substrates supported adjacent respective edge portions thereof in a carrier includes submerging the carrier and substrates supported thereby in a process tank containing a liquid chemical, and a gas distribution plate disposed on the bottom of the tank for directing gas bubbles upward and parallel to the surfaces of each substrate contained in the carrier to ensure that a uniform chemical action occurs. .

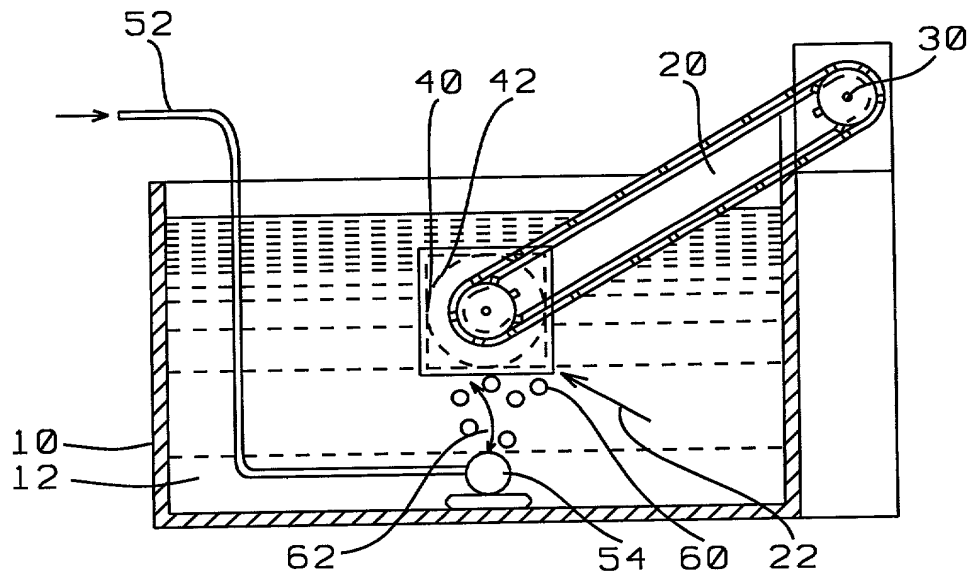


FIG. 1 - Prior Art

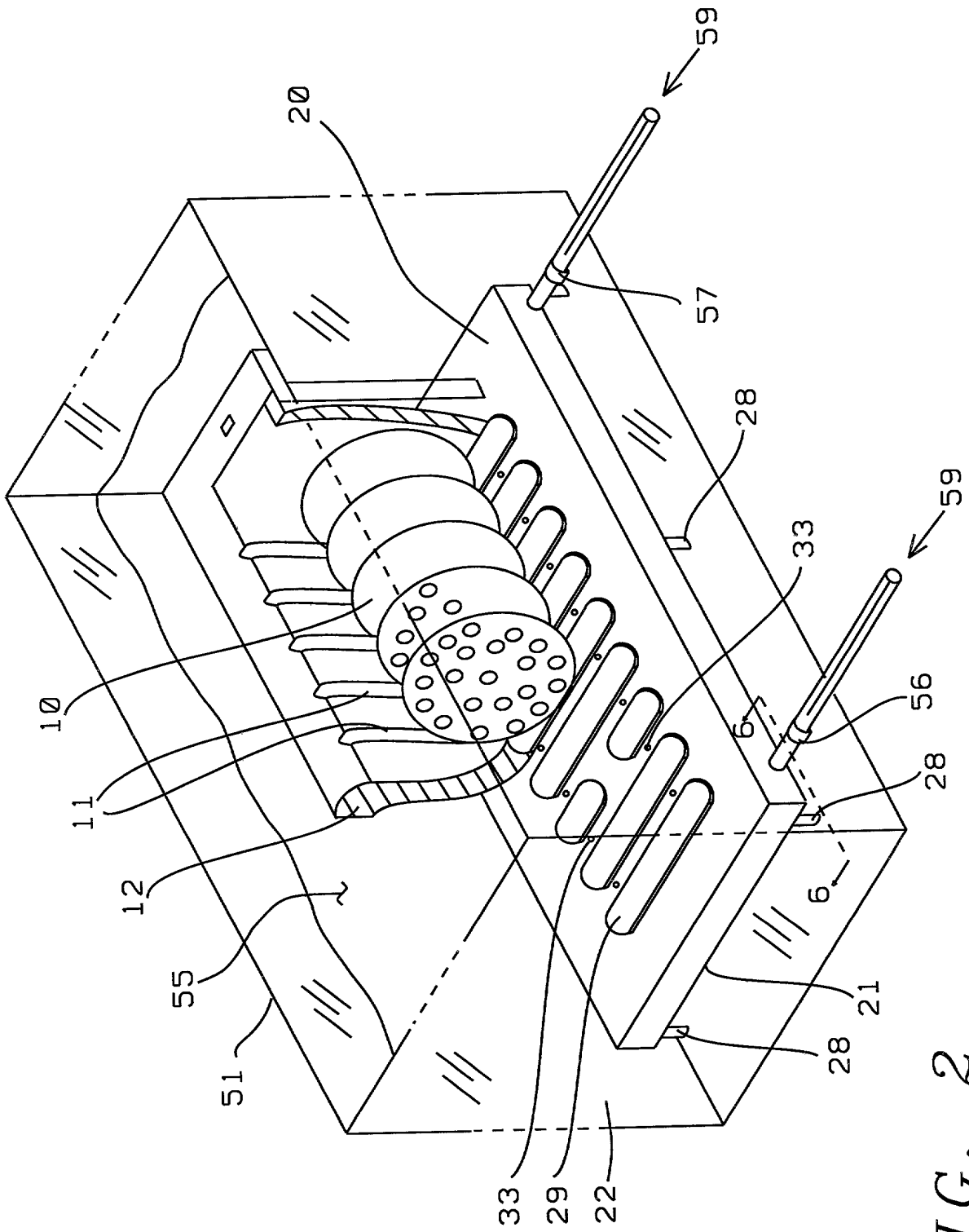


FIG. 2

OFFICE OF THE COMPTROLLER

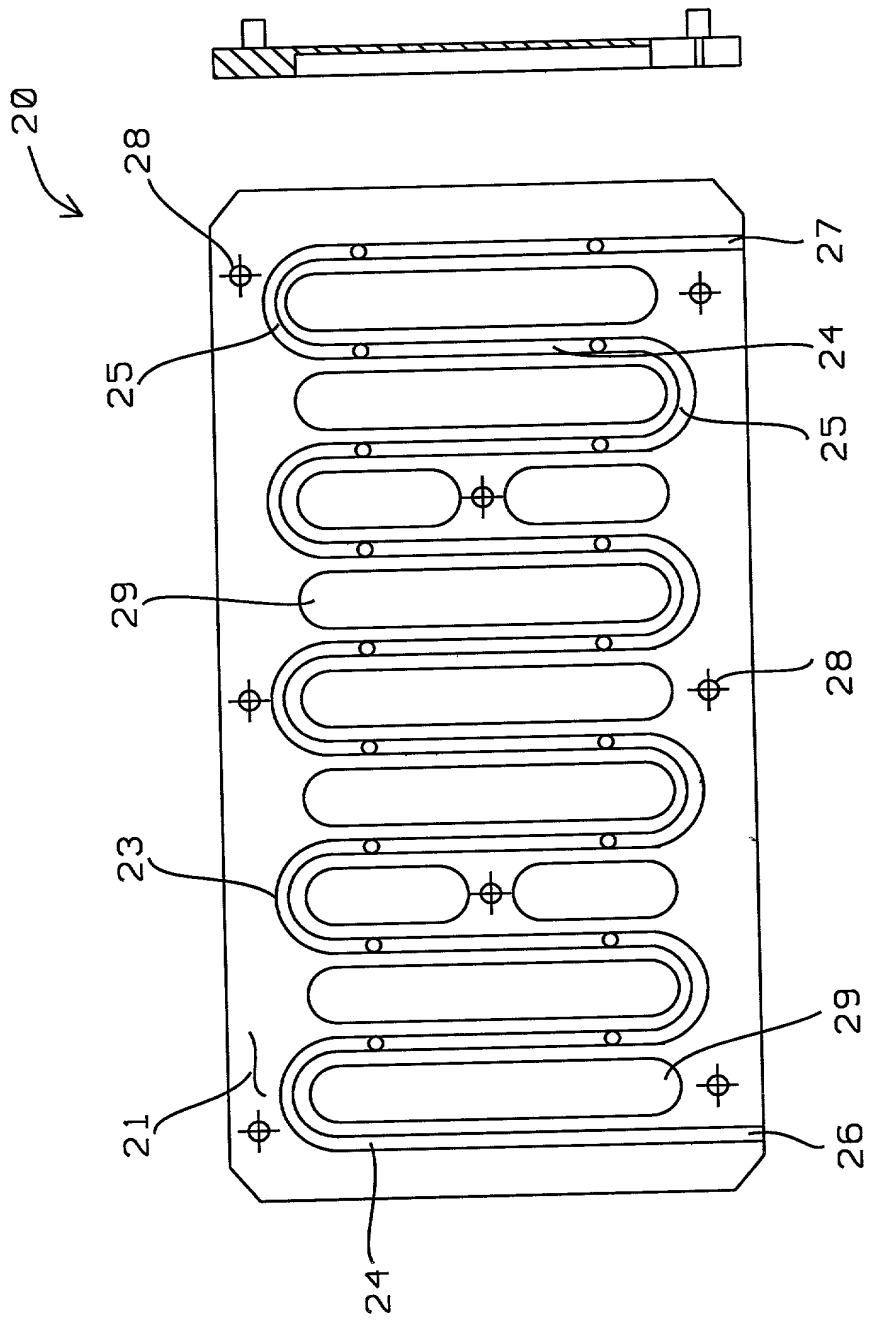


FIG. 3

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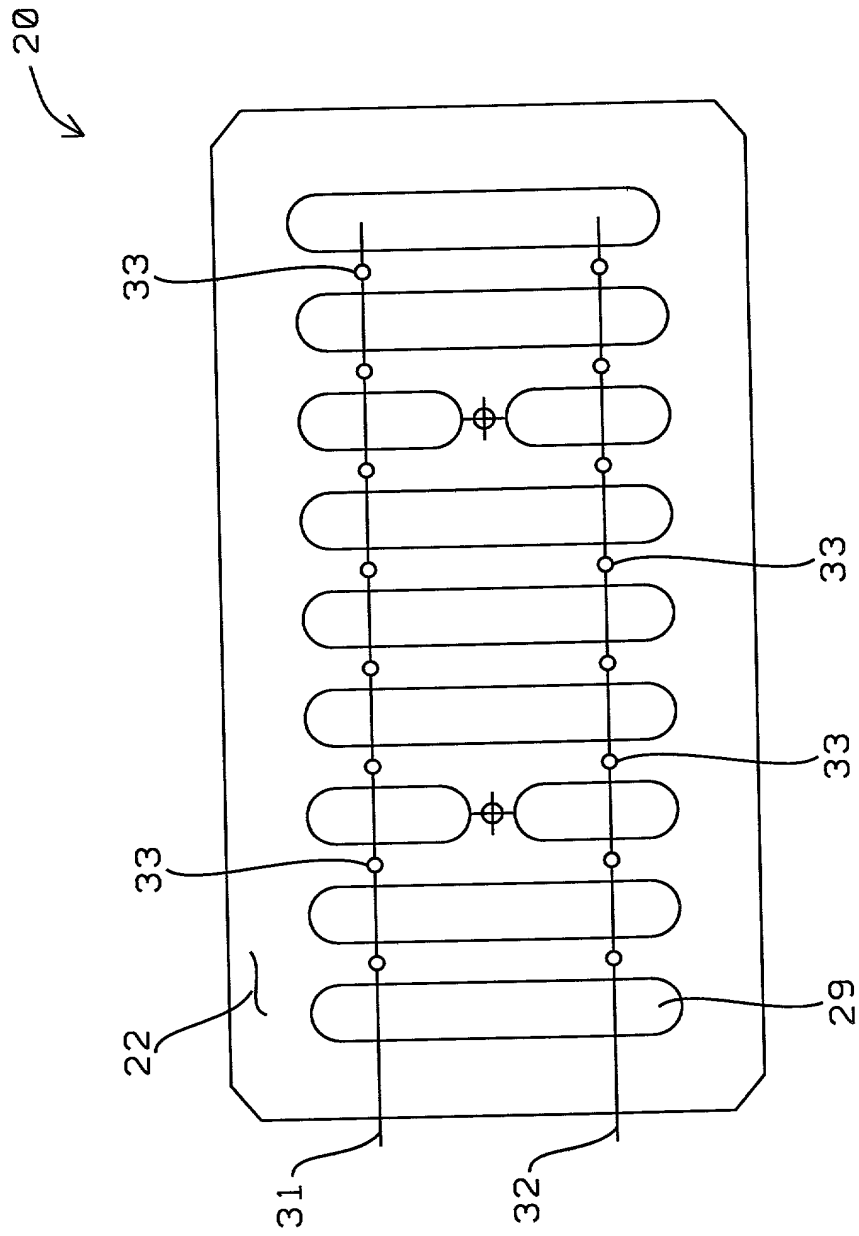


FIG. 4

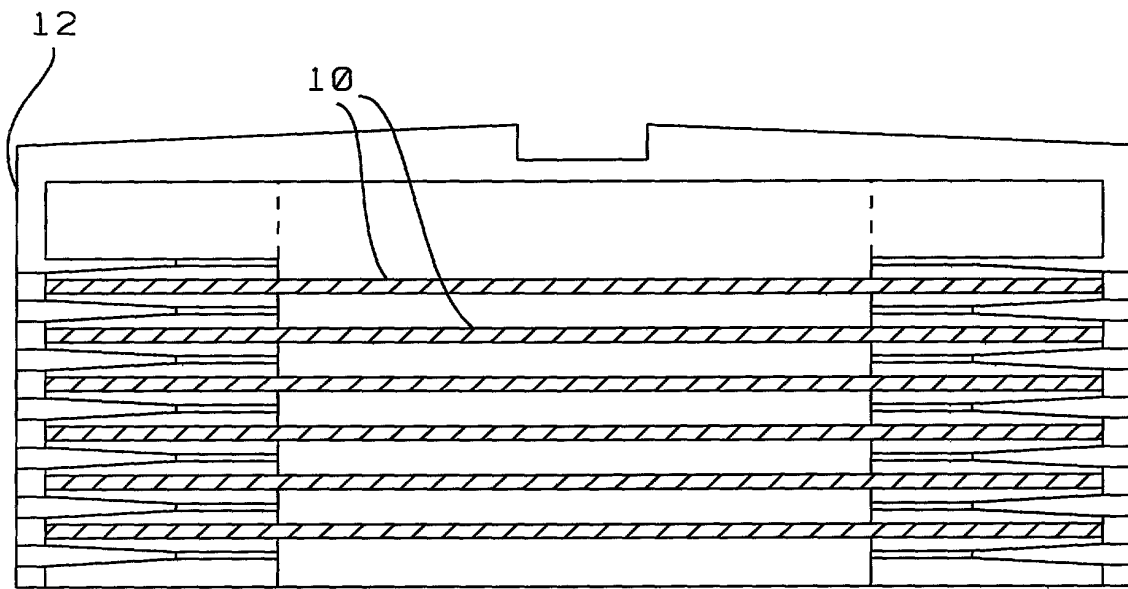


FIG. 5 - Prior Art

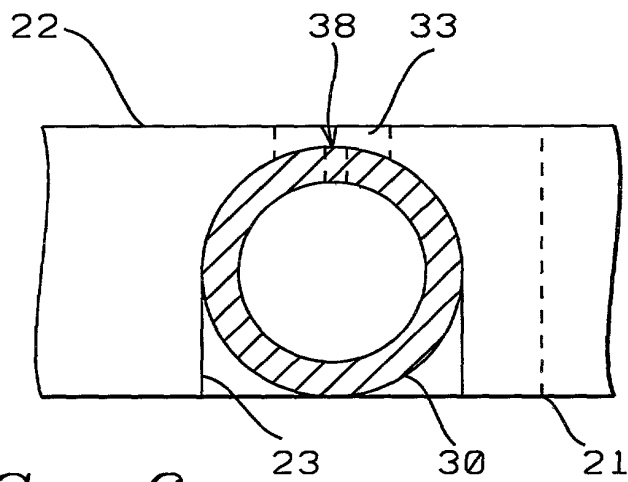


FIG. 6

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

DOCKET NO. TSMC2000-023

As a below named Inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **Photoresist Stripper Using Nitrogen Bubbler**

the specification of which (check one)

☒ X is attached hereto.

☐ was filed on _____

Application Serial No. _____

and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above Identified specification including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Priority Claimed:

(Number)	(Country)	(Day/Month/Year Filed)
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(Number)	(Country)	(Day/Month/Year Filed)
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I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name & registration no.)

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Date

Inventor's signature

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Inventor's signature

Residence

Citizenship

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